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(54) **Pneumatic tyres**

(57) A pneumatic tire comprises a carcass of at least one ply (1) of rubberised metallic cord fabric having its end portions wrapped radially around bead cores (3) to form respective turnups (2). An annular apex strip (5) is disposed between the carcass and each turnup extends radially outwardly from the bead core and contacts the carcass along the axially outward surface thereof. A bead cushion element (7) is positioned axially outwardly of each apex strip and turnup combination. Both the apex strip and bead cushion element are formed of a soft rubber compound of high restorability desirably a compound of Shore A hardness of from 50° to 65° and a rebound elasticity of 55 to 65% determined according to German Industrial Standard DIN 53 512.

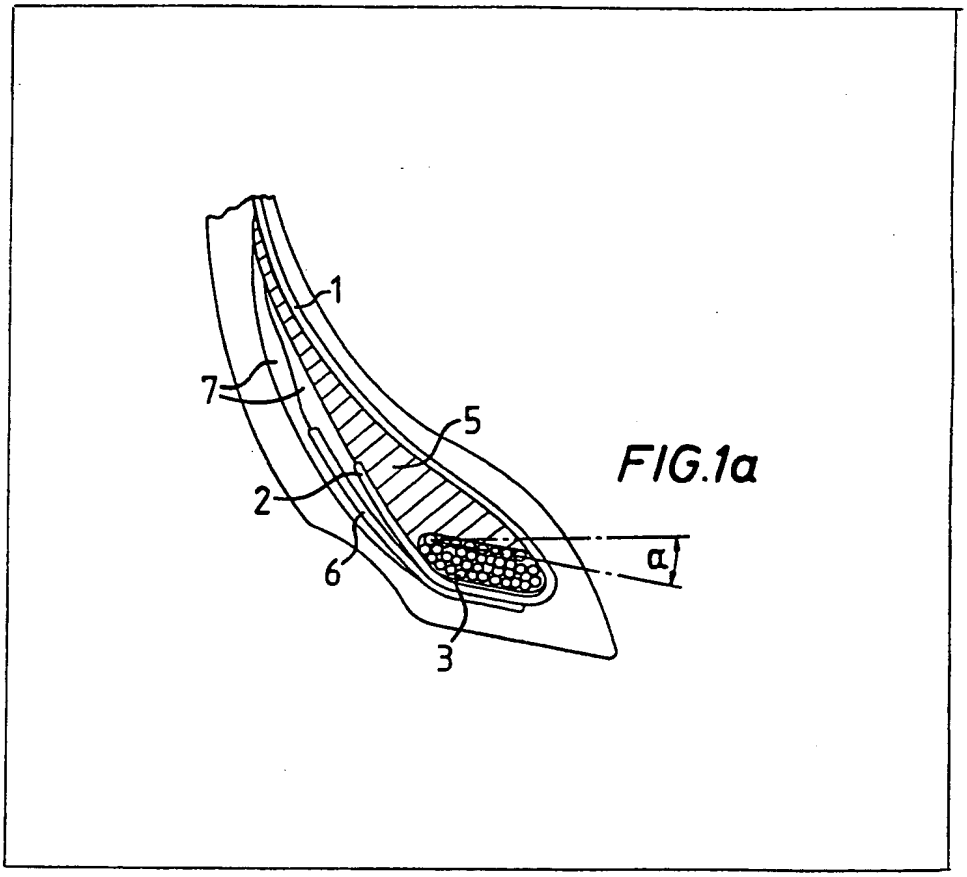

FIG.1a

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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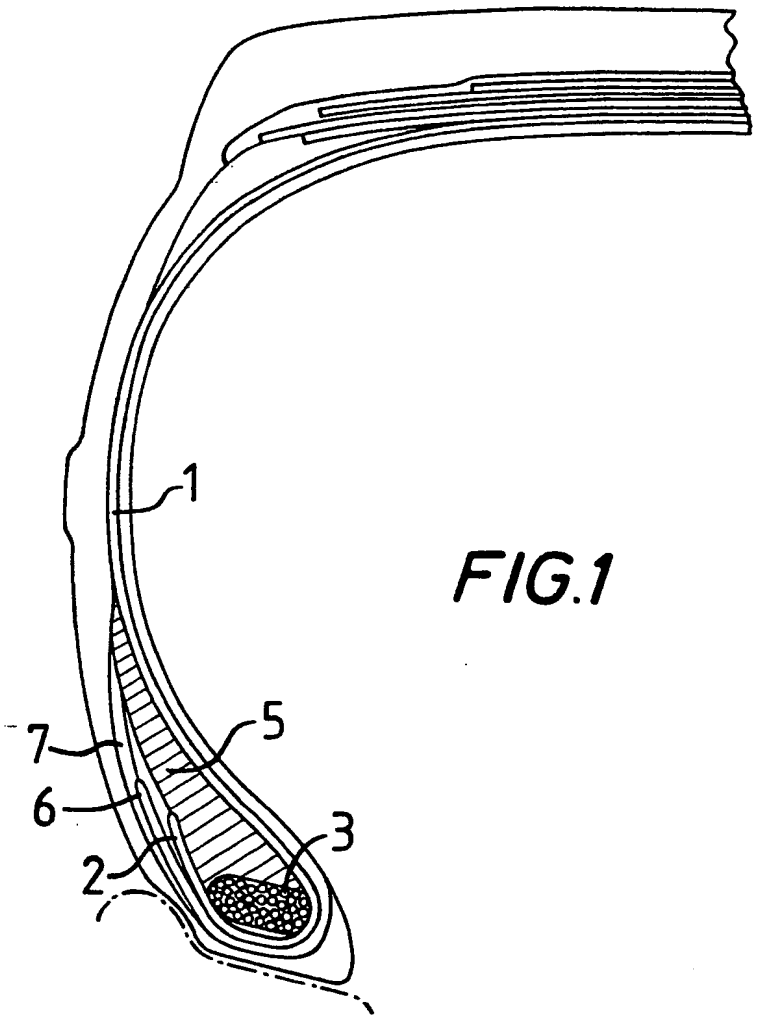

FIG.1

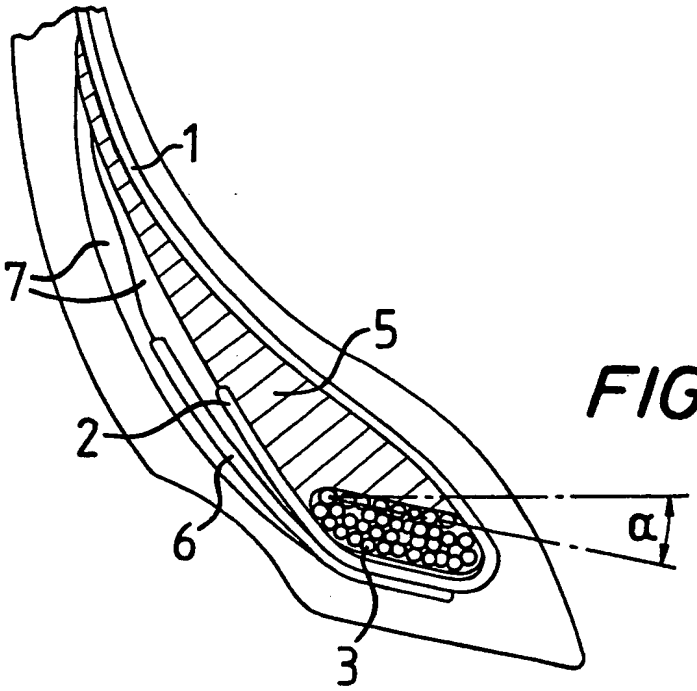

FIG.1a

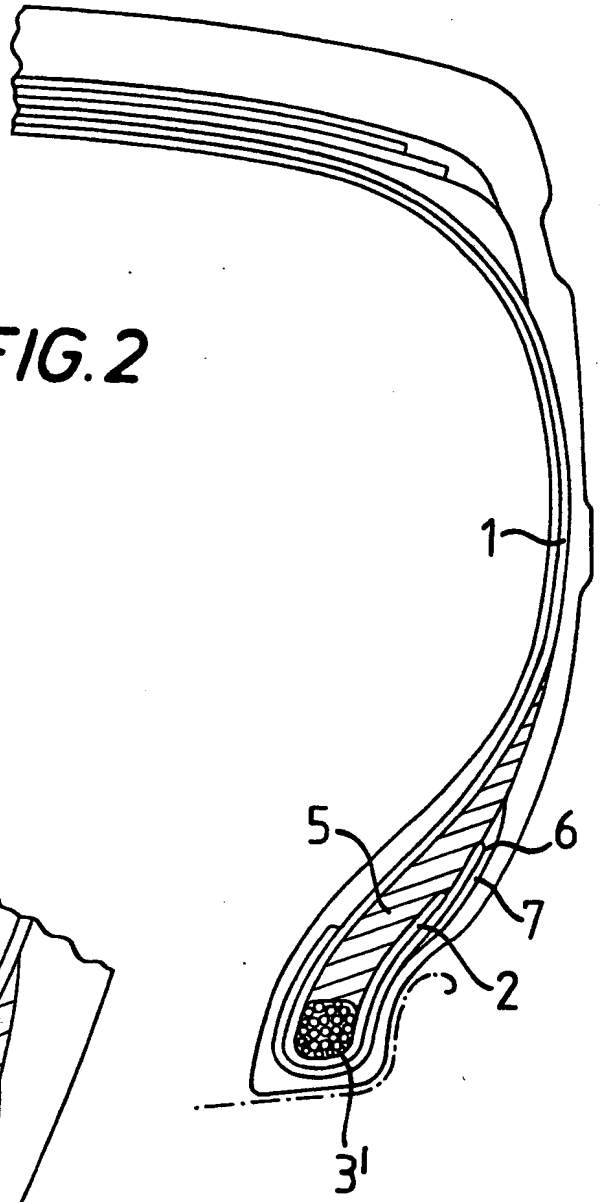

FIG.2

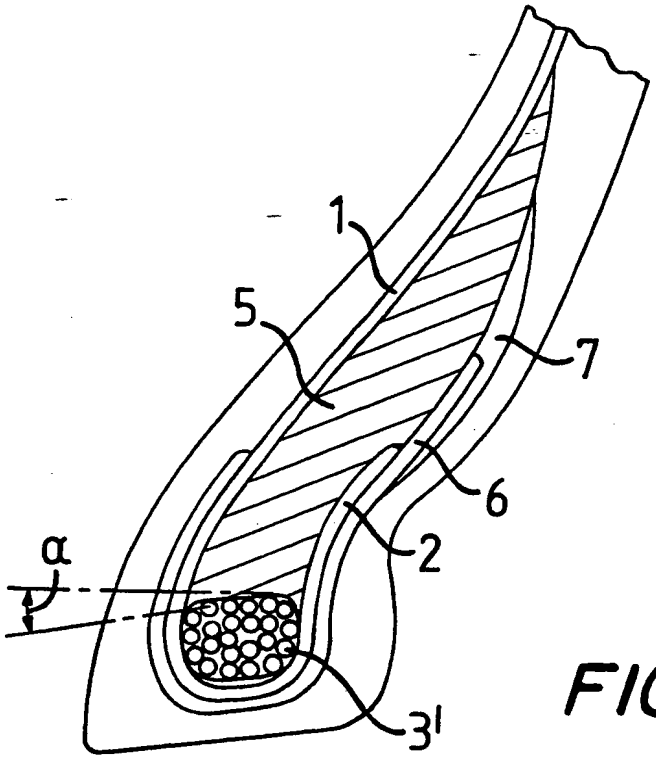

FIG.2a

SPECIFICATION

Pneumatic tire for vehicles

This invention relates to a pneumatic tire for vehicles.

Pneumatic tires are known which comprise a tread portion; sidewalls; a pair of annular bead cores; a carcass of at least one ply of rubberised metallic cord fabric having its end portions wrapped radially around said bead cores to form respective turnups which are axially displaced from the remaining portions of said carcass and an annular apex strip disposed between said carcass and each of said turnups, said apex strips each extending radially outwardly from the respective bead core and contacting the carcass along the axially outward surface thereof.

During the manufacturing of the tire, sharp metallic cutting edges may have been created along those edges of the carcass plies which are cut during the manufacturing process. This is particularly true for heavy duty tires designed for large vehicles. These sharp metallic cutting edges are exposed at the radially outer ends of the turnups and can cause a problem of considerable significance. The tire components adjacent to these reinforced plies are generally rubber compounds that are highly unsuited to constant contact with bare metallic edges under operational load. Because of the multiplicity of forces to which the finished tire is subjected to during operation, there result movements of the individual tire components relative to one another so that the metallic edges of the cord plies and the adjoining tire components tend to rub against each other. The result is a breakdown of the rubber components and, in addition, separtion of the cord from the rubber at the edges of the plies. This results, ultimately, in the complete destruction of the tire.

German Published application No. P 27 10 446.7 describes a pneumatic tire of the aforesaid general construction and shows that the problems resulting from the exposed metallic cutting edges on the turnup can be alleviated by positioning a bead cushion element axially outwardly of each apex strip and turnup combination and in contact with the exposed ply ends. The bead cushion element is formed from a soft rubber compound of high restorability and desirably of a Shore A hardness less than that of the tread portion, sidewalls and carcass plies, partiularly a Shore A hardness of about 60°. Furthermore, the cushion elements may have a rebound elasticity of from 55 to 65% determined according to German Industrial Standard DIN 53 512.

The bead cushion elements absorb and reduce a proportion of the deformation energy active on the metallic cord ends in the bead and sidewall areas when using the tire. Furthermore by incorporating in the cushion rubber compound an additive which improves adhesion of the compound to a metallic cord, particularly to steel, a strong connection between the exposed cord ends and the cushion element is obtained which assists in reducing separation of the cord from the rubber. The apex strip is an essential feature of this tire construction, as it is important that the ends of the metallic cord are held sufficiently far from the carcass. The apex strips are conventionally formed from a hard rubber material, usually of a Shore A hardness of about 80°.

The present invention seeks to further improve the tire construction disclosed in the aforesaid published German application. According to the present invention a pneumatic tire comprises a tread portion; sidewalls; a pair of annular bead cores; a carcass of at least one ply of rubberised metallic cord fabric having its end portions wrapped radially around said bead cores to form respective turnups which are axially displaced from the remaining portions of said carcass; an annular apex strip disposed between said carcass and each of said turnups, said apex strips each extending radially outwardly from the respective bead core and contacting said carcass along its axially outward surface; and a bead cushion element positioned axially outwardly of each apex strip and turnup combination, both the apex strip and the bead cushion element being formed of a soft rubber compound of high restorability.

It will be seen that the invention resides in making the apex strips of a soft rubber compound of high restorability, rather than the hard rubber compounds which have previously been used. Surprisingly, it has been found that this change materially improves the absorption of deformation energy acting at the ends of the metallic cords of the carcass and allows good transmission of the energy for absorption by the bead cores and by the wheel rim on which the tire is anchored by the bead cores. It has been found that the durability of a tire constructed in this way is better than that of the previously constructed tire.

Preferably the apex strip and the bead cushion element are formed from an identical soft rubber compound which has a Shore A hardness less than that of the rubbers of the tread portion, sidewalls and carcass, and desirably has a Shore A hardness of from 50° to 65°. The soft rubber compound desirably has a rebound elasticity of from 55 to 65% determined according to German Industrial Standard DIN 53 512. It is preferred that the compound includes at least one additive which improves adhesion of the compound to steel, and the additives may be one or more of resorcinol, hexamethylene tetramene and active silica. Desirably the soft rubber compound is based on natural rubber, or on a mixture of natural rubber and butadiene rubber, with at least 30% of the mixture being natural rubber.

Further advantage is obtained if each bead core is of substantially polygonal cross section. In particularly suitable constructions this cross section may be substantially hexagonal and of greater axial than radial extent or may be substantially square with rounded corners.

In order that the invention may be better understood, specific embodiments thereof will now be described, by way of example only, with reference to the accompanying drawings in which:-

Figure 1 shows a cross section through half a tire according to a first embodiment of the invention;

Figure 1A is an enarged view of the bead region of the tire of Figure 1;

Figure 2 is a cross section through half a tire according to a second embodiment of the invention; and

Figure 2a is an enlarged view of the bead region of the tire of Figure 2.

Figures 1 and 2 each show a lorry tire having a radial ply carcass 1 with a single ply of rubberised steel cord fabric, having its end portionss wrapped radially around bead core rings 3 to form respective turnups 2. Each tire is symmetrical about its mid-circumferential planes. A bead reinforcement strip 6, which preferably comprises a steel cord layer, is wrapped around the turnup in the bead region and extends radially beyond the turnup. The cords in the reinforcement strip may lie at an angle of substantially 60° to the mid-circumferential plane of the tire, and thus cross the cords of the carcass ply, which are substantially 90° to that plane. The turnup and the bead reinforcement strip 6 are arranged approximately parallel to and axially spaced from the carcass. The tire also comprises a tread, sidewalls and a reinforcing belt between the carcass and the tread.

The bead core rings 3, 3' used comprise rubberised steel wires arranged in inclined radial layers and wound normally to the cross-section of the core. Each layer is inclined from the axial direction of the tire to extend somewhat radially inwardly of the tire, as indicated by the angle α. The layers are arranged to lie substantially parallel to the shoulder (shown by dot-dash lines) of the particular wheel rim on which the tire is to be mounted. Both bead core rings 3 and 3' are able to transfer to the rim the alternating stresses occurring in the carcass wires due to atmospheric pressure and loading without there being any premature fatigue phenomena in the bead due to residual deformation energy.

The space between the carcass 1 and the turnup 2, is filled by an apex strip 5 extending radially outwardly from the bead core ring 3 or 3' to the sidewall area of the tire. A bead cushion element 7 is positioned axially outwardly of the apex strip and turnup combination. For tire building, the cushion shown in Figure 1 comprises individual strips which after vulcanization of the tire form a unitary rubber cushion ply which is also unitary with the apex strip.

Both the apex strip 5 and cushion element 7 are made from the same soft rubber compound of high restorability and desirably with high adhesion to steel. As a result of this the apex strip and cushion element elastically absorb the residual part of the deformation energy in the bead and elastically reduce this energy without stress cracks occurring. Stress differences are also compensated by the elasticity of this rubber compound. Residual forces at the ends of the bead reinforcing strips 6, which constitute the bead elements that are most liable to material fatigue, are kept small and are elastically absorbed. As a result the danger of fatigue cracks in these strips is small. The durability of the more flexible bead is therefore considerably improved in the areas between th carcass, the bead core ring and the strips 6, as well as in the tire sidewall, which means that the tire can usually be retreaded at least two or three times without fatigue phenomena occurring.

The Shore A hardness of the soft rubber compound forming the cushion element and apex strip is less than that of the rubber of the tread portion, sidewalls and carcass and preferably has a Shore A hardness of from 50° to 65° and a rebound elasticity of from 55 to 65% determined according to German Industrial Standard DIN 53 512. A preferred rubber compound for the cushion elements and apex strip has the following composition, the quantities being given in parts by weight, based on 100 parts of rubber:

100 parts of rubber
20 to 30 parts of reinforcing carbon black
2.5 to 3.5 parts of sulfur
5 to 10 parts of active silica
1 to 3 parts of resorcinol
1 to 2.5 parts of hexamethylene tetramine.

The compound will also contain further conventional additives such as zinc oxide, zinc stearate, process oil, adhesive resin, antioxidants, ozone resisting agents and accelerators.

Preference is given to those mixtures in which the rubber is in the form of natural rubber (NR). However, mixtures of natural rubber and butadiene rubbers (BR) are also suitable, particular significance being attached to cis-1,4-polybutadiene rubber. Suitable mixing ratios for the rubber components are 30 to 100 parts, preferably at least 80 parts of natural rubber, for 70 to 0 parts of the butadiene rubber component. The preferred quantity of carbon black is approximately 25 parts and the preferred sulfur quantity is approximately 3 parts. The active silica is preferably used at the lower limit of the above-defined range, preference therefore being given to quantities of about 5 parts or slightly higher quantities. Resorcinol is appropriately used in a quantity of approximately 2.6 parts and hexamethylene tetramine appropriately in a quantity of about 2 parts. Active silica, resorcinol and hexamethylene tetramine all improve bonding of the rubber compound to steel. It may be possible to omit any one or two of these from the compound and still obtain adequate bonding. Other compounds may be used for this purpose for example methylene group donors such as resorcinol-formaldehyde resins, 2-nitro-2-methyl-1-propanol or 1-aza-3, 7-dioxy-5-hydroxy methyl-dicyclo (3.3.0) octane.

N-cyclohexyl-2-benzothiazyl sulfenamide may, for example, be used as the accelerator. However, depending on the choice of rubber it is also possible to use some other suitable accelerator, for example of the sulfenamide type.

The optimum choice of the mixing components leads on the one hand to a high cross-linking density of the rubber and therefore to good adhesion properties between the rubber and the wire ends and on the other hand provides the possibility for the plys to absorb a high proportion of the deformation energy. Due to the high adhesion th rubber and the steel wire ends form under load a unit in which it is very difficult to detach the individual components. In this way a unit is provided which is able to absorb a

larg amount of deformation energy and in which there is little or no effect of destructive friction from th wire ends. Instead the characteristic motions of the wire ends are absorbed by the unit without them causing any significant damage in the remaining tire components.

Herinafter a particular example of a mixing formulation for the rubber ply according to the invention is provided:

100 parts of natural rubber (NR)
25 parts of reinforcing carbon black
5 parts of active silica
1 part of zinc stearate
8 parts of zinc oxide
1.25 parts of process oil
2 parts of adhesive resin
1-2 parts of antioxidant
1-2 parts of ozone resisting agent
2.5 parts of resorcinol
2.1 parts of N-cyclohexyl-2-benzothiazil sulfenamide (CBS)
2 parts of hexamethylene tetramine (HMT)
3 parts of sulfur

Referring further to Figures 1 and 1a, the bead core ring of the tire shown therein is of substantially hexagonal cross section, with the axial extent greater than the radial extent. The bead reinforcement strip 6 terminates radially inwardly of the bead core ring and extends radially outwardly of the tire with an axial spacing provided between the reinforcement strip and the turnup. The cushion element 7 comprises two strips one of which lies between the bead reinforcement strip and the turnup and overlies the cut ends of the metallic cords in the turnup. The other strip overlies the axially outer side of the reinforcement strip and extends beyond the radially outermost extremity of that strip to cover the cut ends of reinforcing cords in the reinforcement strip. The cushion element terminates radially inwardly of the radially outer extremity of the apex strip 5.

Referring to Figures 2 and 2a, in the tire shown therein the cross section of each bead core is substantially square with rounded corners. The reinforcement strip 6 extends from axially inwardly of the carcass ply around the bead region to terminate axially and radially outwardly of the turnup 2. The reinforcement ply thus itself covers the cut ends of the reinforcing cords in the carcass ply. The cushion element 7 is comprised by a single layer which lies axially outwardly of the reinforcement strip and covers the cut ends of the cords thereof, extending radially outwardly beyond those ends to terminate radially inwardly of the radial outer extremity of the apex strip.

In each of these constructions the use of bead core rings of substantially polygonal cross section composed of wires arranged in layers substantially parallel to the wheel rim assists in absorbing the deformation energy and reliably transmitting forces from the tire to the wheel rim. This also assists in giving uniform stress distribution to the individual turns of wire in the bead core rings.

Truck tires having cushion elements and apex strips of soft rubber compound of high restorability have been made and used, and have failed to show separation at the edges of the carcass plies under unfavourable operating conditions in bench and road tests.

CLAIMS:

1. A pneumatic tire comprising a tread portion; sidewalls; a pair of annular bead cores; a carcass of at least one ply of rubberised metallic cord fabric having its end portions wrapped radially around said bead cores to form respective turnups which are axially displaced from the remaining portions of said carcass, an annular apex strip disposed between said carcass and each of said turnups, said apex strips each extending radially outwardly from the respective bead core and contacting said carcass along its axially outward surface; and a bead cushion element positioned axially outwardly of each apex strip and turnup combination, both the apex strip and the bead cushion element being formed of a soft rubber compound of high restorability.

2. A pneumatic tire according to claim 1 in which the apex strip and the bead cushion element are formed from identical soft rubber compound.

3. A pneumatic tire according to claim 1 or claim 2 in which the or each soft rubber compound has a Shore A hardness less than that of the rubbers of the tread portion, sidewalls and carcass.

4. A pneumatic tire according to any one of the preceding claims in which the or each soft rubber compound has a Shore A hardness of from 50° to 65°.

5. A pneumatic tire according to any one of the preceding claims in which the or each soft rubber compound has a rebound elasticity of from 55% to 65% determined according to German Industrial Standards DIN 53,512.

6. A pneumatic tire according to any one of the preceding claims in which the or each soft rubber compound includes at least one additive which improves adhesion of the compound to steel.

7. A pneumatic tire according to claim 6 in which the additives are one or more of resorcinol, hexamethylene tetramine and active silica.

8. A pneumatic tire according to any one of the preceding claims in which the or each soft rubber compound is the vulcanization product of a compound comprising:

(a) from 20 to 30 parts reinforcing carbon black
(b) from 2.5 to 3.5 parts sulfur
(c) from 5 to 10 parts active silicic acid
(d) from 1 to 3 parts resorcinol
(e) from 1 to 2.5 parts hexamethylene tetramine,

all being parts by weight based on 100 parts rubber.

9. A pneumatic tire according to any one of the preceding claims in which the or each soft rubber compound is based on natural rubber, or on a mixture of natural rubber and butadiene rubber with at least 30% of the mixture being natural rubber.

10. A pneumatic tire according to claim 9 in which the butadiene rubber is cis-1,4-polybutadiene rubber.

11. A pneumatic tire according to claim 9 or claim 10 in which at least 80% of the mixture is

natural rubber.

12. A pneumatic tire according to any one of the preceding claims in which each cushion element extends radially outwardly from the respective bead region no further than the radially outward limit of the respective apex strip, and the axially outer surface of each apex strip is in direct contact with the axially inner surface of the respective cushion element over at least the radially outer part of that cushion element.

13. A pneumatic tire according to any one of the preceding claims in which a reinforcement strip of rubberised metallic cord fabric is wrapped around at least the turnup in each bead region, and at least the radially outer terminal edge of the axially outer surface of each reinforcement strip is covered by a respective one of the bead cushion elements.

14. A pneumatic tire according to claim 13 in which part of each bead cushion element lies axially between the respective turnup and its associated reinforcement strip.

15. A pneumatic tire according to any one of the preceding claims in which each bead core is of substantially polygonal cross-section.

16. A pneumatic tire according to claim 15 in which the cross-section of each bead core is substantially hexagonal and of greater axial than radial extent.

17. A pneumatic tire according to claim 15 is which the cross-section of each bead core is substantially square, with rounded corners.

18. A pneumatic tire according to any one of claims 15 to 17 in which each bead core comprises a plurality of layers each composed of a plurality of adjacent steel wires, each layer being inclined from the axial direction of the tire to extend somewhat radially inwardly of the tire.

19. A pnematic tire substantially as herein described with reference to Figures 1 and 1a or Figures 2 and 2a of the accompanying drawings.

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